

PATENT APPLICATION

**METHOD AND SYSTEM FOR TRANSCODING VIDEO AND SPEECH
SIGNALS**

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METHOD AND SYSTEM FOR TRANSCODING VIDEO AND SPEECH SIGNALS

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CROSS-REFERENCES TO RELATED APPLICATIONS

[01] The present application claims priority to U.S. Provisional Patent Application No. 60/275,584 filed March 13, 2001, which is commonly assigned, and hereby incorporated by reference for all purposes.

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STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[02] NOT APPLICABLE

REFERENCE TO A "SEQUENCE LISTING," A TABLE, OR A COMPUTER PROGRAM LISTING APPENDIX SUBMITTED ON A COMPACT DISK.

[03] NOT APPLICABLE

BACKGROUND OF THE INVENTION

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[04] The present invention is related to the field of communications. In particular, the present invention is related to a method and apparatus for transcoding video and audio signals. More particularly, the invention provides a method and system for transcoding information (e.g., video, voice, data) from a first format to a destination format using a proxy transcoder server having a plurality of transcoding processes, where at least one is selected for transcoding the information. Merely by way of example, the invention is applied to a wide area telecommunication network, but it would be recognized that the invention can also be applied across many different types of multimedia protocols over transport networks such as the Internet, a mobile network, a local area network, PTSN, ISDN, SONET, DWDM, and others.

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[05] Telecommunication techniques have improved dramatically over the years. Many different types of networks such as fixed switched, packet based, wireless and

mobile have been deployed. One of the most widely known world wide network called the "Internet" has popularized networking to many people around the world. An increase in use of wide area networks such as the Internet has resulted in many new on-line services such as electronic mail, video telephony, video streaming, electronic commerce, and others. Although computers originally connected to the Internet, other devices such as mobile phones, personal digital assistants, laptop computers, and the like have also been connected. Accordingly, many different types of devices now have access to many different types of services over a variety of networks.

[06] A variety of network elements make up the networks, which connect the aforementioned devices together. Such devices are often connected by gateways and switches that handle transfer of data and conversion of messages from protocols of a sending network to protocols used by a receiving network. Gateways and switches convert analog voice messages to digital formats including G.711 and G.723.1, which are ITU standards. Gateways transmit the converted messages typically in a way similar to transmission of voice over IP. G.711 is an ITU standard for speech codecs that provides audio signals at 64 Kbps using either the A-Law PCM method or the mu-Law PCM method. G.723.1 is an ITU standard for speech codecs optimized for narrow-band networks, including Plain Old Telephone Systems and narrow band Internet connections. The standard uses the LD-CELP method and provides audio signals at 5.3 or 6.3 Kbps. Depending upon the application, there can be many others as well.

[07] As merely an example in Figure 1, a conventional system 100 is shown. This diagram is merely an example and provided for illustrative purposes only. A message originates from a mobile device 105, which is coupled to a wireless network. The message is sent from the mobile device to base station 110 through the wireless network. The base station is coupled to a service station 115, which is coupled to gateway 120. The base station receives the radio message from the mobile device 105, and converts the message, without transcoding, into a digital format, and transmit it to the service station 115. The reformatted message is subsequently transmitted to the gateway which in turns transmit the message to its destination, a user 140, through the Internet 125 and also through a variety of network elements. Such elements may include a gateway 130, a server 135, and others.

[08] One or more gateways may also convert videoconferencing signals from one digital format to another, such as from H.320 to H.323, and transmit converted signals over

the Internet. H.320 is an ITU standard for videoconferencing over digital lines, and it uses the H.261 video compression method, which allows H.320-compliant videoconferencing and desktop systems to communicate with each other over ISDN, switched digital lines and leased lines. H.323 is an ITU standard for real-time, interactive voice and videoconferencing over

5 LANs and the Internet. Widely used for IP telephony, H.323 allows any combination of voice, video and data to be transported. H.323 specifies several video codecs, including H.261 and H.263, and audio codecs, including G.711 and G.723.1. Unfortunately, the audio and video standards have grown well beyond H.320, H.323, G.711, and G.723.1. That is, the proliferation of different standards has caused difficulty in communicating messages between them.

10 Additionally, any communication between such standards has caused a proliferation of complex conversion techniques, which are time consuming and lack efficiency. Accordingly, there is a need for an efficient way to convert information or transcode between various formats in real time. Because some systems such H.320 and H.324 are circuit switched systems (data is transmitted as a continuous stream of bits) and some other systems are packet based, the connection of circuit-based to packet based systems require the demultiplexing of bits from circuit based bitstreams into packet (circuit-to-packet) and vice versa (packet-to-circuit). Note that different system protocols such as H.320, H.323, H.324, 3GPP-324M, SIP and SDP, make use of different signaling methods (to setup connections and exchange terminal capabilities). The inter-connectivity of these systems require the trans-signaling and the conversion of terminal capabilities so terminal can understand what terminals using different protocols are capable of.

[09] From the above, it is seen that an improved way of transferring information from a source to a destination is highly desirable.

SUMMARY OF THE INVENTION

[10] According to the present invention, improved techniques for transcoding in the telecommunication fields are provided. In particular, the present invention is related to a method and apparatus for transcoding video and speech signals. More particularly, the invention provides a method and system for transcoding information (e.g., video, voice, data) from a first format to a destination format using a proxy transcoder server having a plurality of transcoding processes, where at least one is selected for transcoding the information. Merely by way of example, the invention is applied to a wide area telecommunication network, but it would be recognized that the invention can also be applied across many different types of multimedia protocols over transport networks such as the Internet, a mobile network, a local area network, PTSN, ISDN, SONET, DWDM, and others.

[11] In a specific embodiment, the invention provides a system for transferring multimedia information from a source location to a destination location through one or more networks, which may be different. The system has a source output which provides a first stream of information in a first format. The system also has a destination input which receives a second stream of information in a second format. A proxy transcoder server ("PTS") is coupled between the source output and the destination input. The PTS has a transcoding module transcoding data. The PTS also has a capability module identifying a first capability of the source output and a second capability of the destination input, and selecting a transcoding process based upon the first capability and the second capability. Preferably, the selecting is provided using capability mode selection.

[12] In an alternative specific embodiment, the invention provides a system for transferring multimedia information from source to destination locations through one or more networks, which may be different. The system has a source output in a first format, where the source output is coupled to a first network, the source output providing a first stream of information. The system also has a destination input to be received in a second format, where the destination input is coupled to a second network. The destination input receives a second stream of information. A proxy transcoder server ("PTS") is coupled between the source output and the destination input. The proxy transcoder server has a capability process, which is adapted to identify a first capability of the source terminal (which may have different capabilities) and is

adapted to identify a second capability of the destination terminal (which may also have different capabilities). The server also has a transcoding process comprising a plurality of transcoding modules numbered 1 through N, where N is an integer greater than 1. The transcoding process is adapted to selected one of the transcoding process based upon the first capability and the second
5 capability. The proxy transcoder server has a bit rate control process. The bit rate control process is adapted to receive a network status information (e.g., ping) from the first network. The bit rate control is adapted to adjust a status (e.g., stop, prioritize allow, adjust bit rate (by selecting lower bit rate coder)) of the stream of information based upon the network status information.

10 [13] In an alternative specific embodiment, the invention provides a method for processing streams of information. The method includes identifying a source capability from a plurality of source capabilities for a stream of information. The method also identifies a destination capability from a plurality of destination capabilities. A step of selecting a transcoding process from a plurality of transcoding processes in a library based upon the identified source capability and the identified destination capability is included. The method also processes the stream of information using the selected transcoding process if the identified source capability and the identified destination capability are different. The method also transferring the stream of information from the source to the destination free from one of the transcoding processes if the identified source capability and the identified destination capability matches.

20 [14] Numerous benefits are achieved using the present invention over conventional techniques. In a specific embodiment, the invention provides a way to transcode video data from H.263 to MPEG-4 data and vice versa (and between other video codecs), or to transcode audio data from G.723.1 to GSM-AMR (and between other audio codecs) and vice
25 versa. Transcoding can proceed seamlessly so that end points receiving transcoded data do not notice the conversion in preferred embodiments. The invention can also be implemented using conventional software and hardware technologies, such as digital signal processors (DSPs). Depending upon the embodiment, one or more of these benefits or features can be achieved. These and other benefits are described throughout the present specification and more particularly
30 below.

[15] The accompanying drawings, which are incorporated in and form part of the specification, illustrate embodiments of the invention and, together with the description, serves to explain the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

5 [16] Figure 1 illustrates a simplified block diagram of a mobile phone communicating with an end-user.

[17] Figure 2 illustrates one embodiment of the operation of proxy transcoder servers.

10 [18] Figure 3 illustrates another embodiment of the operation of proxy transcoder servers.

[19] Figure 4 is a simplified block diagram illustrating one embodiment of the connectivity of the proxy transcoder server.

[20] Figure 5 is a simplified block diagram illustrating an embodiment of a proxy transcoder server connected to a gateway.

[21] Figure 6 is a simplified flow diagram illustrating one embodiment of the transcoding process.

[22] Figure 7 is a simplified flow diagram illustrating one embodiment of the main system messages.

20 [23] Figure 8 is a simplified flow diagram illustrating one embodiment of the resource messages.

[24] Figure 9 is a simplified flow diagram illustrating one embodiment of the PTS features and mode messages.

[25] Figure 10 is a simplified flow diagram illustrating one embodiment of the PTS maintenance messages.

25 [26] Figure 11 is a simplified flow diagram illustrating one embodiment of the PTS session maintenance and transcoding messages.

[27] Figure 12 is a simplified flow diagram illustrating one embodiment of the PTS session rate control messages.

30 [28] Figure 13 is a simplified flow diagram illustrating one embodiment of the PTS session capability messages.

[29] Figure 14 is a simplified flow diagram illustrating one embodiment of the network addressing messages.

[30] Figure 15 is a simplified flow diagram illustrating one embodiment of the PTS media mixing messages.

5 [31] Figure 16 is a simplified flow diagram illustrating one embodiment of the PTS IPR messages.

[32] Figure 17 is a simplified flow diagram illustrating one embodiment of the PTS software modules.

10 [33] Figure 18 is a simplified flow diagram illustrating symbols used in the flow diagrams.

[34] Figure 19 is a simplified flow diagram illustrating one embodiment of the transcoding procedure.

[35] Figure 20 is a simplified block diagram illustrating one embodiment of a PTS's hardware architecture.

[36] Figure 21 is a simplified block diagram of a computer system that may be used to implement an embodiment of the invention.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

20 [37] According to the present invention, improved techniques for transcoding in the telecommunication fields are provided. In particular, the present invention is related to a method and apparatus for transcoding video and audio signals. More particularly, the invention provides a method and system for transcoding information (e.g., video, audio, data) from a first format to a destination format using a proxy transcoder server having a plurality of transcoding processes, where at least one is selected for transcoding the information. Merely by way of
25 example, the invention is applied to a wide area telecommunication network, but it would be recognized that the invention can also be applied across many different types of multimedia protocols over transport networks such as the Internet, a mobile network, a local area network, PTSN, ISDN, SONET, DWDM, and others.

[38] Parts of the description will be presented in terms of operations performed
30 through the execution of programming instructions according to various embodiments. As will understood by those skilled in the art, these operations often take the form of electrical,

magnetic, or optical signals capable of being stored, transferred, combined, and otherwise manipulated through, for instance, electrical components. Parts of the description will be presented using a distributed computing environment. In a distributed computing environment, file servers, computer servers, and memory storage devices may be located in different places, but they are accessible to local processing units through the network. In addition, program modules may be physically located in different local and remote memory storage devices. Execution of the program modules may occur locally in a stand-alone manner or remotely in a client-server manner. Examples of such distributed computing environments include local area networks of an office, enterprise-wide computer networks, and the global Internet.

[39] Additionally, the following terms are provided to assist the reader in explaining aspects of the invention. Such terms are not intended to be limiting but merely provided for descriptive purposes to one of ordinary skill in the art. Other meanings for the terms consistent with those understood by one of ordinary skill in the art may also be used.

Term	Description
ASIC	Application Specific Integrated Circuit
CIF	Common Intermediate Format
ETSI	European Telecommunications Standards Institute
G.723.1	ITU Recommendation G.723.1, Dual rate speech coder for multimedia communications transmitting at 5.3 and 6.3 kbit/s, 1996
GOB	Group of blocks
GSM	Global System for Mobile communications
GSM-AMR	ETSI Adaptive Multi Rate speech coder. GSM 06.90: "Digital cellular telecommunications system (Phase 2+); AMR speech transcoding", 1998
GSM-AMR	GSM- Adaptive Multi Rate
H.320	ITU Recommendation H.320, Narrow-band visual telephone systems and terminal equipment, 1997

H.323	ITU Recommendation H.323, Packet-based multimedia communications systems, 1998
H.324	ITU Recommendation H.323, Terminal for low bit-rate multimedia communication, 1998
H261	ITU Recommendation H.263, Video codec for audiovisual services at $p \times 64$ kbit/s, 1993
H263	ITU Recommendation H.263, Video coding for low bit rate communication, 1998
IETF	Internet Engineering Task Force
ISO	International Standard Organisation
ITU	International Telecommunication Union
MB	Macro block
MPEG	Moving Picture Expert Group, part of the International Standard Organisation
MPEG2	MPEG audiovisual standards 13818 series
MPEG4	MPEG audiovisual standards 14496 (1-5)
MVD	Motion Vector Data
P Frame or P Picture	Video frame based on predicted information
PTS	Proxy Transcoder Server
QCIF	Quarter CIF (see CIF)
RFC	Request for Comment
SDP	Session Description Protocol
SIP	Session Initiation Protocol
TCOEF or TCOEFF	Transform Coefficients
W3C	World Wide Web Consortium
WAP	Wireless Access Protocol

[40] In a specific embodiment, the term “Proxy Transcoder Server” (herein PTS) is a computer having various modules to carryout some or all of the functionality described herein as well as other functionality, which are known or not known at this present time. The

PTS comprises a host processor, one or more network interfaces, and one or more transcoders. A transcoder may contain, among others, a printed circuit board, an application specific integrated circuit (ASIC), and a field programmable gate array (FPGA). The PTS may be connected to a network host such as a media gateway controller or a soft switch or to a content server such as a video server. The PTS can provide codecs and interfaces to various network architectures and protocols, including WAN, LAN, Mobile, PTSN, ISDN, SONET, and perform one or more of the following functions:

- [41] 1. Capability matching and mode selection;
- [42] 2. Media bitstream transcoding;
- [43] 3. Media bitstream rate control;
- [44] 4. Intellectual property rights management and processing;
- [45] 5. Audio data mixing; and
- [46] 6. Encryption and/or decryption
- [47] The overall function of the PTS is to translate between various protocols,

as exemplified below.

[48] 1. Translating multimedia systems protocols, including the ITU H.32X series, e.g., H.242 and H.245, which are used for conveying the media capabilities of endpoints, and managing media channels and conferences.

[49] 2. Translating media streams including audio and video streams, e.g., translating video streams to and from any pair of video codecs including MPEG2, MPEG4, H.261, H.263, or audio streams to and from any pair of audio codecs including G.723.1, G.729, GSM-AMR, EVRC, SMV, and QCELP.

[50] 3. Translating IP management protocols and IP rights markings. For example, the PTS may extract IP rights information from MPEG4 streams and process the information in accordance with IP rights-related operations in order to maintain the IP rights in the media.

[51] 4. Encrypting and/or decrypting signals if necessary.

[52] Hence, the PTS has a variety of audio and video transcoding capabilities. Selection of capabilities affects overall qualities of service (QoS) in multimedia communication, and should therefore be determined based on the connection bandwidth and load of the gateway to which the PTS is coupled. The PTS can transcode for different media contents including

MPEG series, H.26X video series, GSM-AMR, and G.72X audio codec series. Furthermore, the PTS' transcoding capabilities can be easily upgraded, at least in part due to its programmability.

[53] In addition, the PTS can perform media bitstream rate control. The rate control is necessary because the connection between two end-points may involve bandwidth reduction, e.g., from wired to wireless network. The PTS may perform rate control using information from network channel allocation as supplied by the network access provider, or using in-band bandwidth management requests, which can be originated from end-points through command and control protocols, e.g., H.242 and H.245.

[54] Moreover, the PTS can perform intellectual property (IP) rights management and processing. For example, the PTS may identify a data set regarding intellectual property rights, and use it to facilitate the management and processing. In one embodiment, MPEG4 supplements coded media objects with an optional intellectual property identification (IPI) data set, which carries information on contents, types of contents, and IP rights holders. The data set, if present, forms part of an elementary stream descriptor describing streaming data associated with a media object. The number of data sets associated with each media object may vary; and different media objects may share the same data set. The provision of the data sets allows the implementation of mechanisms for audit trail, monitoring, billing, and copy protection.

[55] Multimedia communication applications have wide ranges of requirements for IP rights protection and security. Some applications require protecting information that users exchange in order to preserve privacy, even if the information has no intrinsic value. Other applications require high-grade management and protection for information of importance to its creator and/or distributors. In addition, the framework of IP rights management and processing must generally be flexible so as to access various forms of IP rights data, as required by a specific application, and as stored in a particular bitstream.

[56] Although the description that follows shows a PTS connected to a gateway as a stand alone device, alternate embodiments of the PTS may use a PTS connected to a switch, a server, a router or any device connected to a network. In addition, a PTS may be integrated into a gateway, a switch, a router or other device connected to a network to form an integral part of that network device. Further details of other embodiments are provided below.

[57] Figure 2 illustrates an embodiment wherein a PTS transcodes signals between a mobile end-point and a LAN phone. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. A mobile end-point 210 communicates audio and video information with a LAN phone 220. The transmitted information travels from the mobile end-point 210 to a Base Station 230 via a radio communication channel, e.g., an air link, and subsequently to a Master Service Controller 240, to a near-end gateway 250, through the Internet 260, to a far-end gateway 270, to a LAN switch 280, and finally to the LAN phone 220.

[58] Because of limitations of an air-link and mobility of the mobile end-point 210, the bandwidth between the mobile end-point 210 and the base station 230 may reach several tens or hundreds of Kbps, much smaller than the bandwidth between Internet routers and the LAN phone 220. The latter bandwidth reaches 10s to 100s of megabits per second (Mbps). In Figure 2, the media coding and decoding capability of the mobile end-point 220 is GSM-AMR for audio signals and MPEG-4 for video signals. In contrast, the media coding and decoding capability of the LAN phone 230 is G.723.1 for audio and H.263 for video. The differences in capability and bandwidth make important transcoding performed by PTS in the path between the mobile end-point 220 and the LAN phone 230, to facilitate substantially real-time communications. In addition, transcoding by PTS prevents overloading a mobile network 290, because the PTS performs a throttling function.

[59] In Figure 2, audio signals need to be transcoded between G.723.1 and GSM-AMR, while video signals need to be transcoded between MPEG4-video and H.263. Such transcoding may be performed by either a PTS 204 in the mobile network 290 or a PTS 208 in a landline network 292. Thus the two PTS's 204 and 208 are not necessary to perform the transcoding. But implementing one PTS in each network allows the bandwidth requirement at each gateway to become smaller. In addition, even though the embodiment illustrated in Figure 2 shows transcoding by PTS, the PTS's can also allow transmission of signals without transcoding.

[60] Figure 3 illustrates a block diagram of yet another embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations,

modifications, and alternatives. A mobile handset 310 communicates information with a video content server 320. The video server 320 streams movies containing audio and video signals. The audio signals are encoded using MPEG2-Audio Level 3 (MP3) and the video signals are encoded using MPEG2-video. Due to the mismatch in bandwidth and capability between the video server 320 and the mobile handset 310, the PST 304 in a mobile network 390 would transcode the audio to GSM-AMR and the video to MPEG4-video. But if the PST 308 in a video server network 392 performs the transcoding, the bandwidth requirement for a gateway 350 in the mobile handset network 390 may be reduced.

[61] In yet another embodiment, the capabilities of two end-points of communication may be specified using Wireless Access Protocol (WAP) User Agent Profile information (Capabilities and Preferences Information), the web consortium CC/PP (using the Resource Description Framework, or RDF), the IETF standards (RFC 2506, RFC 2533, and RFC 2703) or ITU's H.245 or H.242 standards, or a combination thereof. In yet another embodiment, a gateway may, under the assistance of PTS, detect the capabilities of end-points and the bandwidth available or allocated for transmission of media. The PTS may then select a data coding mode and transcode the media to best meet the requirements of the end-points. Hence, the PTS may serve as a proxy for each end-point side, converting bitstreams in one form appropriate for one side to another form appropriate for the other side.

[62] Figure 4 illustrates a block diagram of an PTS according to an embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. Logical ports are defined as abstract communication ports. Several logical ports may exist on one physical network interface, but a PTS may have more than one physical network interface. A network gateway controller interface (NGCI) 420 may comprise at least one NGCI logical port for messaging between a PTS 410 and a gateway or a network host. The gateway may perform call signaling between end-points. The gateway may be a media gateway controller, or any other gateway device that establishes call or transport function between end-points. Call signaling is the process of establishing the initial link between end-point entities, by exchanging network addresses of the source and the destination of a media stream to be transcoded. For real-time Internet protocol, call signaling establishes Internet protocol addresses and Internet protocol port numbers for the

source and the destination of a media stream. Call signaling could also involve more sophisticated processes, such as that required by SIP or H.323.

[63] Media network interfaces (MNI) 430 provide logical ports for reception and transmission of media bitstreams. Through these logical ports, the PTS 410 receives media bitstreams, e.g., audio signals, video signals, command and control data, and other data that could be text or binary. Port addresses for receiving bitstreams by the PTS 410 and the destination addresses to which the transcoded streams are transmitted are specified by a messaging protocol between the call signaling gateway and the PTS 410 through the NGCI 420. The underlying physical interface of the MNI 430 could be a Gigabit network interface card, time domain multiplexed (TDM) circuit-switched connections such as E1/T1/OC3. The MNI 430 physical network interfaces may or may not share the physical link of the NGCI 420.

[64] A monitor and setup interface (MSI) 440 is used for initial configuration, monitoring, and reconfiguration of the PTS 410. The physical link over which the MSI data are carried may be shared with other network connections or may be carried through a dedicated serial connection port. Many connectivity scenarios exist for a PTS, including connecting to a gateway e.g., a media gateway controller, and connecting to a content server, e.g., a video server.

[65] Figure 5 illustrates the connectivity of a PTS according to an embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. A MNI 530 connects a PTS 510 to the Internet 550, via a router or switch 540, and a NGCI connects the PTS 510 to a content server (or gateway 560 can be a gateway mediating between two end-points, e.g. a mobile and an IP phone) 560 via the NGCI 520. The MSI 530 may also in connection to the content server 560 if the content server can provide basic terminal emulation support, e.g., hyper-terms under Windows. In one embodiment, the gateway or content server may be a network host.

[66] Figure 6 illustrates various PTS functions the means of an operation cycle according to an embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. Once a PTS is connected to the network, e.g., a network host or a router, and is powered-up and configured, the PTS is ready to accept the initiation of transcoding sessions from the network host.

[67] At step 606, the PTS receives a message from either a gateway or from a content server. At step 608, the PTS determines if the received message is a session message. If the message is a session message, at step 632, the PTS decides if the message is a start of session message. A session may be initiated by a network host through a messaging protocol operated over the NGCI, such the MGCP or the H.248/MEGACO protocols. One or more sessions can be active at any time. Once a session is started, basic operations of the PTS for that session are controlled by further messages.

[68] If the message received is a start of session message, at step 650, the PTS starts a new session. If the received message is not a start of session message, at step 634, the PTS decides whether the received message is a session maintenance message. If it is a session maintenance message, the PTS commences a session maintenance process at step 652. The session maintenance process may involve maintaining or terminating a connection for a session. If the received message is not a session maintenance message, at step 636, the PTS decides whether the received message is a transcoding message. If the message is a transcoding message, at step 654, the PTS processes the transcoding message. If the message is not a transcoding message, at step 638, the PTS determines whether the received message is a rate control message. If the received message is a rate control message, at step 656, the rate control message is processed. The rate control process may direct the PTS to dynamically adjust the transmission rate in order to efficiently utilize the transmission bandwidth and to prevent transmitted packets from being dropped.

[69] When the PTS transcodes a bitstream, the optimal data rate produced by the PTS depends on media protocol of the network between the PTS and the destination of the bitstream. The data rate received by the destination varies, depending on network congestion, type of link between a router and the destination, e.g., wired connection or wireless connection, protocol and data multiplexing associated to the link, and the quality of the link. The destination may receive a data rate higher than it can process, resulting in buffer-overflow. On the other hand, the destination may receive a data rate lower than the rate it expects to receive, resulting in buffer-underflow. Therefore, the PTS may have to regulate its data rate to avoid both buffer-overflow and buffer-underflow.

[70] The PTS regulates its data rate with at least the following methods. The PTS may use network congestion information, bandwidth information, quality information from

the network host or the network access provider, or from internal PTS mechanisms to calculate roundtrip time. The roundtrip time between the PTS and an end-point, e.g., source or destination of a bitstream, can be measured by sending a "ping" packet to the end-point. The total time for the "ping" packet to reach the end-point and for the response packet from the end-point to reach the PTS is the roundtrip time. The more congested the network is, the longer is the roundtrip time. Hence the roundtrip time can be used to assess the congestion level of the network at current PTS bit-rate.

[71] Alternately, the PTS may assess the network congestion using in-band information. For example, the PTS may receive from an end-point, instructions to reduce or to increase its bit-rate throughput, under protocols such as H.245 used in H.324 and H.323.

[72] Either the in-band method or the roundtrip-time method may be used to maintain adequate quality of service given instantaneous network conditions. The PTS uses the congestion and bit-rate information to determine an adequate coding mode that yields an appropriate bit-rate with the following methods.

[73] In one embodiment, the PTS may change transcoding parameters to satisfy service goals in real-time operation. For example, in MPEG4-video, the quantization parameters can be changed to yield a low bit-rate throughput. But the change may lead to degradation in video quality. Therefore if video quality is important, advanced coding techniques such as that provided by H.263 and MPEG4 may be used to reduce the bit-rate throughput without degrading quality. But these methods may impose higher computation requirements. Hence, the PTS rate control strategy should provide a desired balance between signal quality, bit-rate and computation.

[74] The rate control in audio is achieved similarly although most audio codecs cannot provide fine-grained variable rates, but instead provide a number of bit rates that the PTS can select from. For example, the G.723.1 audio codec provides two bit-rates, a low rate and a high rate. Similarly, the GSM-AMR codec supports eight bit-rates, ranging from 4.75 Kbps to 12.2 Kbps. The PTS may use a lower rate if the network path to the end-point has congestions, or if the bandwidth allocated to the link with the end-point has a low bandwidth.

[75] In yet another embodiment a PTS may instruct the network equipment such as a router to give a higher priority to the data being handled by the PTS, if the network equipment supports prioritization of data delivery. For instance, version 6 of the Internet

protocol provides support for prioritization of packets. Also, the IETF has developed standards for resource reservation that allows end-points to reserve bandwidth. The PTS may exploit this packet prioritization and resource reservation if they are supported by network in which the PTS is being deployed. For example, the Internet protocol provides facility for assigning priority to packets, and the PTS can use this facility to prioritize packets when needed. In addition, the PTS may support internal prioritization of its own connections so connections of higher priority are processed as soon as they become practical.

[76] Turning back to Figure 6, at step 640, the PTS determines whether the message received is a capability message. A capability message is a message that contains capabilities of the end-points. If the message is a capability message, at step 658, the PTS processes this message. The PTS can process the message defining capabilities of end-points. For example, if the end-points are a video server and a mobile terminal, the capabilities of the video server and the mobile terminal are conveyed to the PTS. Consequently, the PTS determines the best mode of communication between these two end-points. In choosing the best mode, the PTS takes into account the protocol associated with the specific video content that the mobile user would like to view. Different types of contents may be encoded with different protocols, e.g., MPEG2 and MPEG4. In addition, the capabilities of the mobile terminal may be communicated to the PTS via the network host in numerous ways. For example, the PTS may obtain the capabilities from information stored in the mobile terminal, from the user subscription information stored in the network database of the user's service provider, or in-band within the bitstream exchanged between the mobile terminal and the network access gateway during the call signaling phase. The format of the capabilities includes among others ITU, IETF, and WAP.

[77] A capability message may be sent by the network host to the PTS to find the best transcoding mode for a specific media to be transmitted from one end-point, e.g., a video server, to the other end-point. In the capability-mode-selection process, the PTS may choose one bitstream protocol mode for receiving data from the source, and another bitstream protocol mode to which the PTS convert the received media.

[78] In yet another embodiment, the selected modes for each end-point may be signaled to the respective end-point in order to open bitstream transport channels. In H.323 or H.324, the network uses H.245 logical channel operations or Fast Connect procedures to open such channels. Using H.245 logical channel operations, an end-point may send an "open logical

channel” request to the other end-point in order to transmit signals. In H.323, an end-point can encapsulate information about media channels through which the end-point is ready to transmit signals by using a “fast start” message encapsulated in the call signaling information, exchanged in the initial setup of the call under, for example, the ITU Q.931 standard as recommended by H.225.0. Therefore, given the selected protocols for the end-points, the network host or the PTS can establish transport channels for a media bitstream. The opening process depends on the system level protocol of the overall connection between the end-points mediated by the network.

[79] Before the PTS can transcode, the selected media transmission modes have to be associated with a source address and a destination address, and the information of such association has to be communicated to the PTS via messages. The association may result from opening a logical media channel by one of the end-points as done in the H.245 standard. This implicit opening of a logical media channel when the PTS selects the types of media transmission modes can be explicitly requested by the gateway or the content server, or could be pre-programmed under some standard requirements. Regardless of the means for specifying the source address or the destination address, the association between selected media transmission modes and the source or destination addresses informs the PTS where to get the input bitstream and where to send the transcoded bitstream.

[80] In a specific embodiment, the PTS reads the bitstream from the source address, translates the bitstream from its original format to the target format, and sends the converted bitstream to the destination address. The reception and transmission of bitstream data is performed with network read/write functions, using the network hardware-specific software.

[81] Turning back to Figure 6, at step 642, the PTS determines whether the message received is a network-addressing message. A network-addressing message contains information about network addresses for the source and/or the destination of a bitstream. If the message received is a network-addressing message, at step 660, the PTS processes the network-addressing message. At step 644, the PTS determines whether the message received is a media-mixing message. A media-mixing message is a message requesting the PTS to mix signals associated with two or more audio streams and retransmit the mixed bitstreams to a network destination address. If the received message is a media-mixing message, at step 662, the PTS processes the media-mixing message. At step 646, the PTS determines whether the message received is a IP rights message, and if so at step 664 the PTS manages the information regarding

IP rights contained in the received message, according to instructions in the message. Some media communication and representation protocols support interfacing with IP rights management and processing, and accessing information regarding IP rights contained in bitstreams. For example, the PTS may support the MPEG-4 interface specification for IP rights management and processing. The information regarding IP rights is extracted or demultiplexed from MPEG4 bitstreams and made available to the network host via the messaging system. The IP rights specific applications installed on the network host or plugged into the PTS then access and process such information for various purposes, including record keeping, resigning of the content, and blocking.

[82] At step 610 in Figure 6, the PTS determines whether the received message is a features and mode message and if so, at step 622, the PTS processes this message. Processing a features and mode message includes activating features and options that are related to transcoding, mixing and other options associated to the session. At step 612, the PTS determines whether the received message is a resource message, and if so, at step 624, the PTS processes this message. Processing a resource message includes processing the PTS resources in terms of hardware processing resources, memory resources, and other computing or networking resources that the PTS manages. If the PTS receives instructions that the media being received and thereafter transmitted needs to be encrypted, the PTS transcodes and thereafter encrypts the transmitted data. Similarly, the PTS may decrypt data in response to instructions received.

[83] In the above, the capabilities of the PTS are illustrated as discrete steps, but one skilled in the art will appreciate that one or more of the discrete steps may be combined or further subdivided to perform functions of the discrete steps. Depending upon the embodiment, the functionality described can be separated or even combined. The functionality can be implemented in software and/or hardware including any combination of them. Depending upon the embodiment, there can be many other modifications, variations, and alternatives.

[84] Figures 7, 8, 9, and 10 are simplified flow diagrams illustrating an embodiment of the main system messages. These diagrams are merely examples, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. The main system messages allows the PTS to respond to instructions from a network equipment such as a media gateway controller. The messages includes instructions to start a session, end a session, set session options, get

session options, send a message to session manager, get message from session manager, set PTS mode, get PTS mode, set PTS feature, get PTS feature, get resource status, set resource status, update firmware procedure, get PTS system status, reset the PTS, shutdown the PTS, and activating debug/tracing mode.

[85] Figures 11-16 are simplified flow diagrams illustrating an embodiment of the PTS session maintenance and transcoding messages. These diagram are merely examples, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. The session maintenance and transcoding messages allow the PTS to terminate a session, open/close transcoding channel, set/get transcoding options, updating end-point capabilities, match end-points capabilities, select end-point capabilities, activate rate control, get rate control mode, get rate control mode, add/remove media destination addresses, add/remove media source addresses, set/get IPR modes, set IPR options, activate mixing of media channels, disable mixing, and set channel mixing mode.

[86] Figure 17 shows a block diagram illustrating software modules that may be used in a PTS according to an embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. The PTS software comprises the following main modules:

- [87] 1. A session management module 1710;
- [88] 2. A PTS management module 1720;
- [89] 3. A network host interface module 1730;
- [90] 4. A media channel processing module 1740;
- [91] 5. A call signaling interface module 1750;
- [92] 6. A network interface module 1760;
- [93] 7. A transcoding module 1770;
- [94] 8. A rate control module 1780;
- [95] 9. An intellectual property rights management module 1790; and
- [96] 10. A capabilities processing module 1792.

[97] The session management module 1710 performs the main services of a gateway, and is thus the main PTS software program. For example, the session management

module 1710 starts and ends transcoding sessions, handles and dispatches session messages, and manages session resources. The PTS management module 1720 performs basic overall management functions necessary if an operator needs to inspect the status of the PTS or to manage its resources. For example, the management module 1720 tests main hardware components with component specific testing procedures, resets the PTS, and tracks and allocates transcoding resources dynamically. The network host interface module 1730 handles communication-messaging interface between the PTS and the network host, e.g., a media gateway controller or a content server. For example, the interface module 1730, depending on type of network host, implements messaging between the network host and the PTS, implements commands defining methods by which transcoding capabilities are captured by the PTS or defined for the PTS. In addition, the interface module 1730 may implement methods by which the PTS retrieves media content types from bitstreams when capability exchanges are not explicitly performed. The media channel processing module 1740 performs media channel function, such as opening, closing, adding and removing channel network sources and destinations. The call signaling interface module 1750 performs functions for establishing initial call setup between end-points through the PTS, where the procedure for call setup depends on standard, such as SIP and Q.931. The network interface module 1760 provides basic input and/or output communication interfaces. The basic input and/or output is the lowest level of communication over which more complex messaging is performed.

[98] The transcoding module 1770 performs the actual transcoding function including transcoding between MPEG series, H.26X video series, GSM-AMR and G.72X audio codec series. Other examples of PTS transcoding may include at least MPEG2-audio to MPEG4-audio, G.723.1 to GSM-AMR, MPEG2-video to MPEG4-video, H.263 to MPEG4-video. The rate control module 1780 performs a throttling function and prevents network segments over which the end-points communicate from being overloaded. The intellectual property rights management module 1790 protects the IP rights. For example, the management module 1790 uses data on IP rights in a bitstream, and assists on implementing mechanisms for auditing, monitoring, billing, and protection of the IP rights associated with the received and transcoded bitstream. The capabilities processing module 1792 utilizes data in received messages to find the best matching mode for the specific media that is transmitted from one end-point to another.

[99] The architecture of a PTS determines performance, cost, and time-to-market of the server. Performance may be considered as the number of simultaneous gateway channels or calls that the PTS may simultaneously process. Furthermore, for a fixed number of channels, the cost and performance of the architecture will depend on the following factors:

[100] 1. Bus architecture;

[101] 2. Transcoding architecture and hardware for various video and audio transcoding;

[102] 3. Network off loading for connecting to MGC and other gateway components; and

[103] 4. Operating System.

[104] Figure 18 shows an explanation of the symbols used in the flow charts. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives.

[105] Figure 19 shows a simplified flow chart illustrating the high-level procedure for video bitstream transcoding that may be used in a PTS according to an embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. The procedure reads a chunk of bits and if the end-sequence marker is detected then it ends. Otherwise it reads the next code word, transcodes the code word to the output protocol codeword, updates the history record and emits the transcoded bits to the output buffer which is flushed according to a rate control scheme as to avoid that the input buffer at the receiving end-point does not over-flow.

[106] Figure 20 illustrates a PTS hardware architecture according to an embodiment of the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. The architecture features an intelligent transcoding node 2010, which is a bus card including one or more processors, a bank of DSP processors 2020, one or more network interfaces 2030, one or more processors 2040, and a memory bank 2050. This architecture has several advantages. First, the network interface 2030 is embedded in the intelligent transcoding node bus-card 2010. Hence the call processing and

transcoding are performed locally on the bus-card 2010. Second, one or more network interfaces per processing node are possible. Third, the architecture can support a large number of simultaneous calls because of compactness of its processing modules.

[107] In addition to the embodiment in Figure 20, numerous architectures for a PTS are possible, a few of which are listed below:

- [108] 1. Standalone chassis with bus-cards;
- [109] 2. PC-like implementation as described below;
- [110] 3. Firmware to existing processing hardware, including ASICs;
- [111] 4. Software running on existing hardware;
- [112] 5. Software running on existing hardware with hardware acceleration by the means of ASICs, DSPs, or other types of processors; and
- [113] 6. ASIC chipset.

[114] Figure 21 shows an embodiment of a computer system according to the present invention. This diagram is merely an example, which should not unduly limit the scope of the claims herein. One of ordinary skill in the art would recognize many other variations, modifications, and alternatives. The present invention may be implemented in a personal computer (PC) architecture. Alternative computer system architectures, or other programmable or electronic-based devices may also be employed.

[115] In Figure 21 a computer system 2100 comprises a bus 2101 for communicating information, a processor 2102 coupled to the bus 2101 for processing information, random access memory 2103 coupled to the bus 2101 for storing information and instructions for the processor 2102, a read-only memory 2104 coupled to the bus 2101 for storing static information and instructions for the processor 2102 and PTS applications, a display device 2105 coupled to the bus 2101 for displaying information for a user, an input device 2106 coupled to the bus 2101 for communicating information and command selections to the processor 2102, and a mass storage device 2107, e.g., a magnetic disk and associated disk drive, coupled to the bus 2101 for storing information and instructions. A data storage medium 2108 contains digital information, e.g., PTS software modules, and it is coupled to the bus 2101 and configured to operate with mass storage device 2107 to provide the processor 2102 access to digital information stored on the data storage medium 2108 through the bus 2101. A hardware transcoding acceleration module 2109 comprises printed circuit boards, Digital Signal

Processors, ASIC's, and FPGA's. The module 2109 is communicatively coupled to the bus 2101, and may have an embodiment similar to the intelligent transcoding node 2010 as shown in Figure 20.

[116] Processor 2102 may be any of a wide variety of general purpose processors or microprocessors, e.g., the Pentium™ processor manufactured by Intel Corporation, and a MIPS processor manufactured by MIPS Technologies, Inc., of 2011 N. Shoreline Blvd., Mountain View, CA 94039-7311. Other varieties of processors such as digital signal processors (DSP's) may also be used in the computer system 2100. The display device 2105 may be a liquid crystal device, cathode ray tube (CRT), or other suitable display device. The mass storage device 2107 may be a conventional hard disk drive, a floppy disk drive, a CD-ROM drive, or other magnetic or optical data storage device for reading and writing information stored on a hard disk, a floppy disk, a CD-ROM, a magnetic tape, or other magnetic or optical data storage medium. The data storage medium 2108 may be a hard disk, a floppy disk, a CD-ROM, a magnetic tape, or other magnetic or optical data storage medium.

[117] In general, the processor 2102 can retrieve processing instructions and data from the read-only memory 2104. The processor 2102 can also retrieve processing instructions and data from the data storage medium 2108 using the mass storage device 2107 and downloads the information into the random access memory 2103, which may be a SDRAM. The processor 2102 then executes an instruction stream from the random access memory 2103 or read-only memory 2104. Command selections and information input at the input device 2106 may direct the flow of instructions executed by the processor 2102. Input device 2106 may be, among others, a pointing device such as a conventional mouse or a trackball device. The execution results may be displayed on the display device 2105. The computer system 2100 also comprises a network device 2110 for connecting the computer system 2100 to a network. The network device 2110 may be an Ethernet device, a phone jack, a satellite link, or other device.

[118] Embodiments of the present invention may be represented as a software product stored on a machine-accessible medium, also referred to as a computer-accessible medium or a processor-accessible medium. The machine-accessible medium may be any type of magnetic, optical, or electrical storage medium including a diskette, a CD-ROM, a memory device, either volatile or non-volatile, an ASIC, a firmware to an ASIC, a system-on-chip, or other storage mechanism. The machine-accessible medium may contain various sets of

instructions, code sequences, or configuration information. Other data necessary to implement the present invention may also be stored on the machine-accessible medium. As merely an example, transcoding techniques are described in U.S. Provisional Serial No. 60/347270 (Attorney Docket No. 021318-000200US), commonly assigned, and hereby incorporated by reference for all purposes.

[119] In addition to media transcoding that the PTS can perform, it can also perform system protocol transcoding. A multimedia system protocol is typically an umbrella of protocols that define how multimedia end-points can connect to each other, can issue and interpret commands (such streaming or opening a video channel), can tear down connections, can join conferences. A system protocol typically covers the following important aspects: call signalling, command and control, media transports aspects, and media coding aspects. For example the H.323 system protocol standard covers H.225.0/Q.931 for call signalling and media transports, H.245 for command and control, and a number of audio and video codecs. The H.324 system protocol standard covers H.223 (media and data bitstreams multiplexing), H.245 for command and control, and a number of audio and video codecs. Although some aspects of H.323 and H.324 are similar, H.323 is packet based whereas H.324 is circuit based. Hence for H.323 and H.324 end-points to communicate, system protocol transcoding needs to be performed, at the call-signaling level, command and control levels and media coding levels. The PTS performs both system protocol transcoding and media (audio and video) transcoding. From the PTS point of view, the Call signaling transcoding is the process of proxying the end-points (H.324, H.323, SIP, RTSP, and others) so they can connect to each other. From the command and control point of view, the PTS performs the transcoding so messages such as terminal capabilities, open/close logical channels, etc., are translated so they can be understood by the terminal receiving the command and control message. The PTS has to perform translation of the issued messages it receives from the sending end-point so they could be understood by the receiving terminal. In terms of media transport, the PTS needs to access data by demultiplexing from circuit bearer channels, extracting the media service data units, transcoding the media bits and then packaging the transcoded bits so they can be sent in a format the receiving end point can understand. If the receiving end point is H.323, the packaging would involve RTP packetization. So the media transport transcoding (translation) consists of circuit-to-packet, packet-to-circuit and packet-to-packet translation of the media bits. When the transport is circuit

based, the typically the media bits are multiplexed in a Time Domain Multiplexing (TDM) fashion.

[120] While there has been illustrated and described what are presently considered to be example embodiments of the present invention, it will be understood by those skilled in the art that various other modifications may be made, and equivalents may be substituted, without departing from the true scope of the invention. Additionally, many modifications may be made to adapt a particular situation to the teachings of the present invention without departing from the central inventive concept described herein.

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